Life Studies of Metal Films on Beta"-Alumina at High Temperature

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Applications of metallic films on sodium beta"-alumina solid electrolyte, BASE, in technology for the alkali metal thermal to electric converter, AMTEC, include both electrodes and structural components such as seals. (1) Both types of component must maintain their performance on BASE in a sodium atmosphere at about 1125K for the life of the AMTEC device. We have previously reported on the stability of the BASE electrolyte and several electrodes under AMTEC operating, or slightly accelerated, conditions. (2-6) While the requirements for metallic seals are very different than those for AMTEC electrodes, the interface between the BASE and the bonding layer of the metal seal may be investigated by using electrochemical techniques which are commonly used to characterize electrodes for AMTEC.

Electrochemical techniques including electrochemical impedance spectroscopy yield information about the metal-BASE interface capacitance, and hence its area, as well the charge transfer resistance of the interface and its dependence on frequency, which reveals the porosity of the metal film to sodium and the extent or perimeter of the three phase (solid electrolyte, metal, vacuum) interface. This information is most thoroughly known for molybdenum films on BASE, which are good electrodes if maintained below 1100 K.(7) Molybdenum films are also a potential bonding layer for seal fabrication, along with other active refractory metals such as vanadium, niobium, and titanium. The critical requirement for these metals as bonding layers is that they must form a coherent adhesive bond to BASE, but that either de-adhesion or further reaction between the metal layer and the BASE must not occur significantly over the life of the device. This data may be obtained from operting AMTEC cells or sodium exposure test cells.(8)

In addition, the stability of seal morphology and strength must also be investigated , and in general electrochemical methods are less useful than exposure tests for these purposes. Thin films on BASE are studied as is, or after brazing a metal foil to the metal film. Exposure chambers are evacuated stainless steel tubes with refractory metal liners such that the liner extends into the cooler part of the tube. A small amount of sodium metal is introduced into the tube before it is evacuated and sealed, and with the cool end of the tube controlled between 573 and 773K, provides a known pressure of

Evidence collected during this and previous studies indicates the chemical stability of Mo, W, WPt, and WRh films on BASE in sodium vapor for periods of up to 4000 hours, at temperatures as high as 1173K. Ti alloys result in some degradation of the BASE surface, with inclusion of Ti, and both Cr and Mn lead to decomposition of BASE with formation of Cr2O3 and MnAl2O4 as well as Al2O3

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